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PC-12/47E, YAW DAMPER TRIM ACTIVITY

1   INTRODUCTION

PC-12/47E MSN 1020 crashed on the 29th September 2008 near Santa Fe, New Mexico, USA. The rudder trim tab was found deflected fully to the right, meaning full left rudder trim [1].

A fully deflected trim tab could have been the result of one of the following scenarios:

1. Pilot commanded trim position

2. Trim runaway due to an electrical fault (not interrupted in acc. with the AFM)

3. Yaw-damper commanded position

Pilatus have conducted dedicated flight tests using PC-12 SN 545. A similar flight path to the one of accident aircraft MSN 1020 was flown with auto-pilot/yaw-damper engaged, the results are presented herein.

2   MAIN SECTION

2.1   YAW DAMPER AND YAW TRIM FUNCTION

The yaw damper function provides stability augmentation and turn coordination for the aircraft yaw axis via servo control of the rudder servo. Whenever the YD is active, the yaw auto-trim function is also active, [2].

The yaw damper includes an auto-trim function that automatically operates the aircraft rudder trim system in order to off-load steady torque from the rudder servo whenever permitted thresholds are exceeded, [2].

It is normal practice to engage the yaw damper shortly after take-ff and only disengage it prior to the landing (on short final), refer to AFM, [4].

TO	EC, NTSB, PilBAL					
CC						
Department	ER	EA	ER	E		
Approvals	Author	Checked	Approved	Approved		
Name/Sign.						
Date	06-Feb-09	12 Feb 09	13.02.09	13.2.09		

2.2   DEFINITION OF RUDDER AND RUDDER TRIM TAB ANGLES

2.2.1   Rudder

The nominal rudder deflections are, [3]:

34° - 36° right

24° - 26° left

As shown below, positive values are for left rudder.

Data

Print Screen

FTI Calibration   PC12 P02 /15.01.2009

Mnemonic: **RUDD_POS**
Description: **Rudder position**
Comment: Rudder control surface to the left: Positiv
Valid from: F-305
Date of calibration: 15.01.2009
Operator: K. Walker

Test equipment:	Typ: Rudder Calibration tool	Sensor: Potentiometer Vishay
	SN:	SN:
	Calib. Date: N/A	Range: 340°

x^1   -1.1310E-01
x^0   1.2863E+01

RSQ   0.999929

x-Values mV/V	y-Values [DEG]	Function [DEG]	Abs. Error [DEG]	rel.Error [%]
441.8	-37.00	-37.103	0.103	0.15%
247.1	-15.00	-15.083	0.083	0.12%
111.5	0.00	0.253	-0.253	-0.37%
-20.7	15.00	15.204	-0.204	-0.30%
-156.2	30.80	30.529	0.271	0.40%

Note: Larger then nominal deflections can be achieved when deflecting the rudder by hand and compressing the rudder soft stop.

2.2.2   Rudder trim tab deflection

The nominal rudder trim tab deflections are, [3]:

Trim tab left (moves rudder right):   12.5° - 14°

Trim tab right (moves rudder left)   6° - 8.5°

As indicated below, positive values are for trim tab left.

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Data	FTI Calibration	PC12 545 / 15.01.2009

Mnemonic:	**RUDD_TRIM_POS**	
Description:	**Rudder trim position**	
Comment:	Rudder trim control surface to the left: Positiv	
Valid from:	F-305	
Date of calibration:	15.01.2009	
Operator:	K. Walker	

Test equipment:	Typ:	Trim Calibration tool	Sensor: Aircraft system
	SN:		SN:
	Calib. Date:	N/A	Range:

x^1	2.3844E-01	
x^0	4.4895E-01	
RSQ	0.999982	

TIU Values Deg	Trim Tap [DEG]	Function [DEG]	Abs. Error [DEG]	rel.Error [%]
59	14.50	14.517	-0.017	-0.08%
0	0.50	0.449	0.051	0.24%
-29	-6.50	-6.466	-0.034	-0.16%

2.3   FLIGHT TEST RESULTS

During flight test 12-545-F-305 flown on the 15th January 2009, a left hand approach to runway 07L of Buochs airfield, LSZC, was flown, simulating the final part of the MSN1020 approach. See Figure 1 below for the MSN 1020 flight path.

The full data set is contained in file 12-545-F-305-1Hz.cvs located on K:\F_E\EA\Pc-12\Test Data\PC-12 545\Excel Data\12-545-F-305.

Data between 14:21:03 and 14:25:13 (rows 5800 and 6050 in the excel sheet) covers the approach as shown in Figure 2.

The final, quite steep descent (point 234 to 235 in Figure 1) had obviously to be flown over the runway as can be seen in Figure 2 and Figure 3.
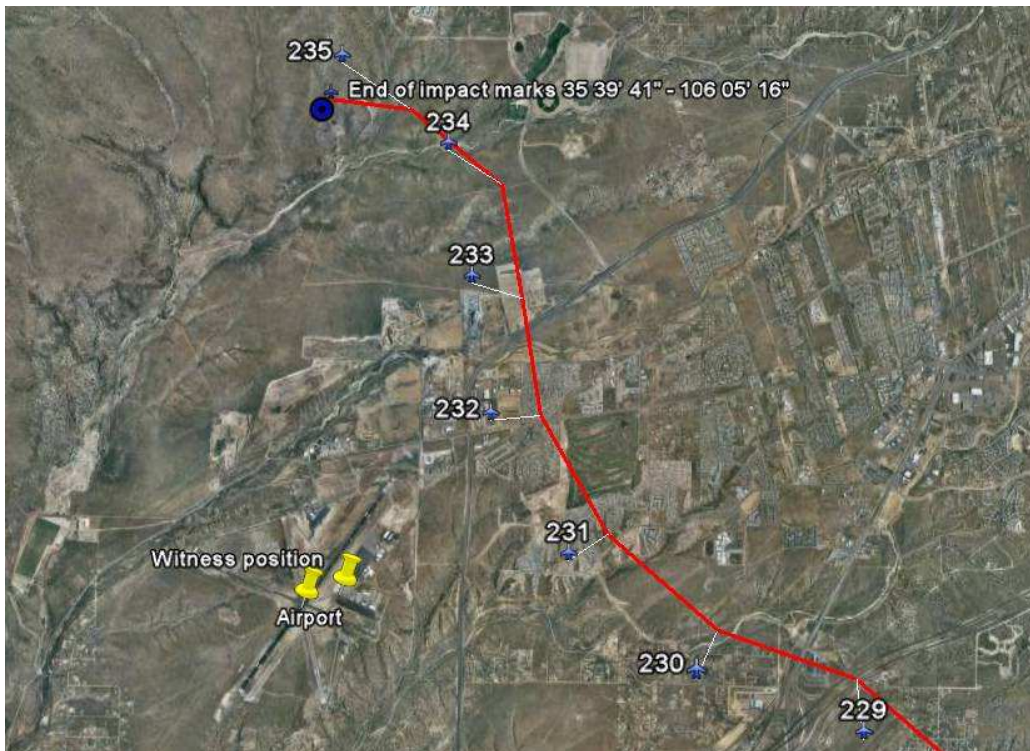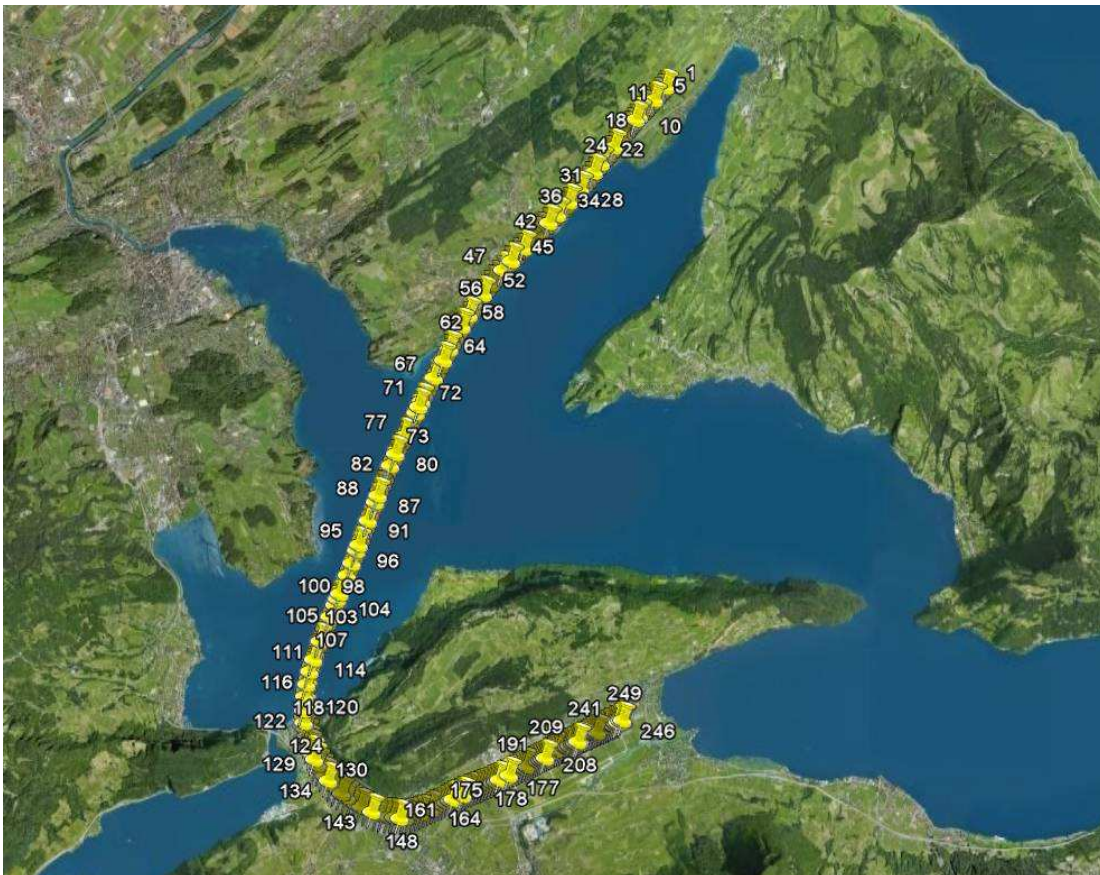
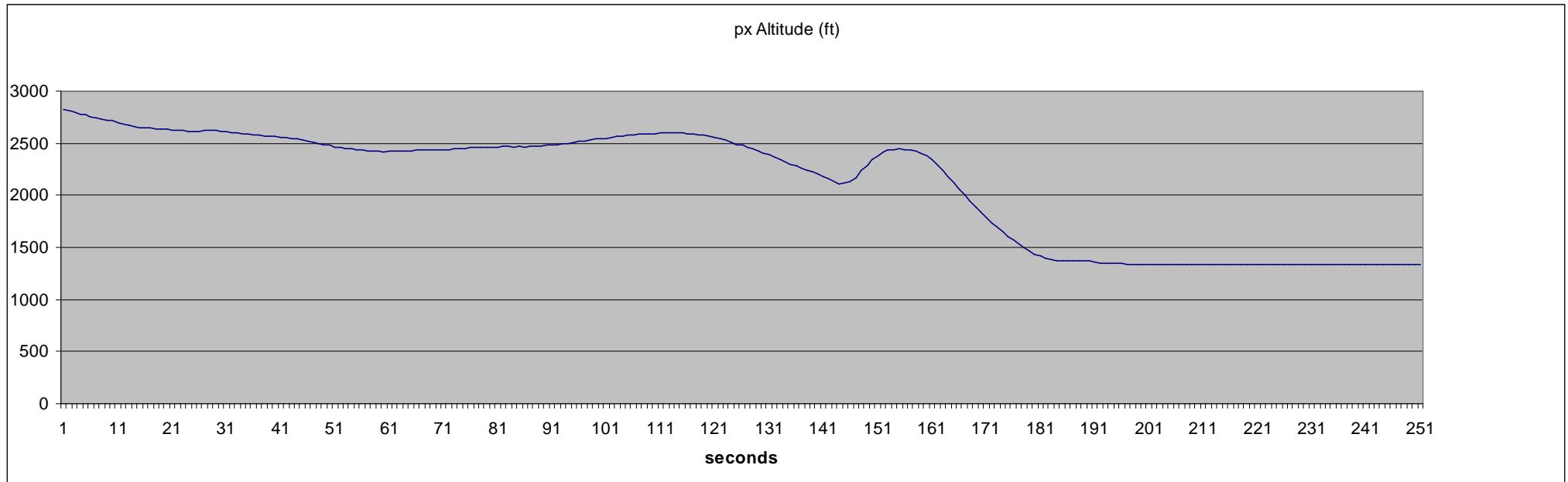Figure 1 MSN 1020 flight path

Figure 2 Approach to LSZC RWY 7L

Figure 3 Approach altitude profile (airport altitude 1473ft)

For the time frame covered in Figure 2 and Figure 3, the following parameters are shown in Figure 4 below:

- "Yaw" angle in degrees   Note: The real yaw angle ß is not available from the instrumentation. The angle shown is actually the difference between track and magnetic heading and does therefore also include crab angles due to wind (variation is negligible). It is only given for reference and to show that no excessive yaw angles occurred.

- Yaw rate (deg/sec)

- Rudder angle (deg)   Positive values for rudder left

- Rudder trim angle (deg)   Positive values for trim tab to the left (right trim)

- Engine torque (psi)

- Speed (KCAS)

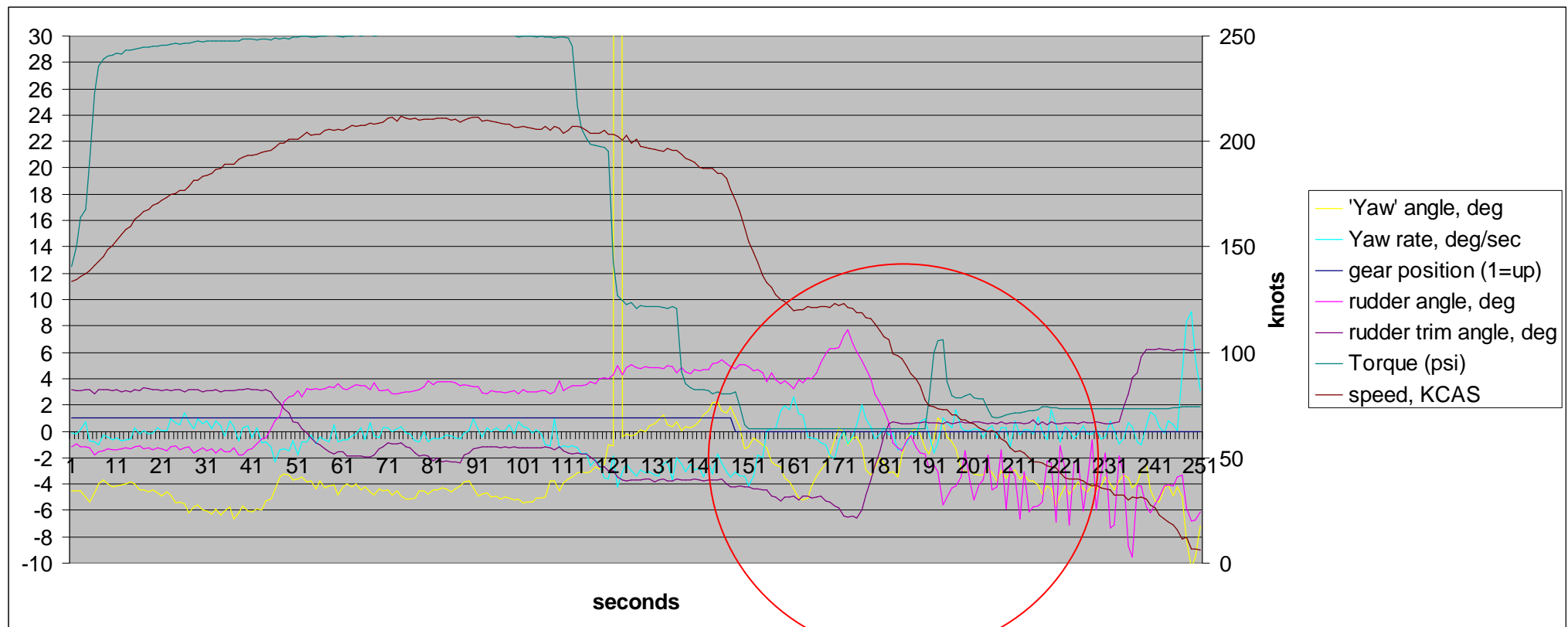- Gear position　　　　　　　　0 for gear down, 1 for gear up

Figure 4

In the above chart, it can be seen that from an initial slight right trim (~3°) with associated minor right rudder deflection (≤2°), the trim setting changed gradually to full left around data point 175. At this point (shortly before touchdown, refer to Figure 3) the rudder trim angle had reached -6.5 deg, which is full left trim. The rudder deflection was around 4° left for most of the approach and peaked shortly at 8°. Figure 5 below shows the 50 sec before touch-down. At 175 sec, the parameters were as follows:

Power: idle
Flaps: Approx 10°   (refer to EXCEL file)
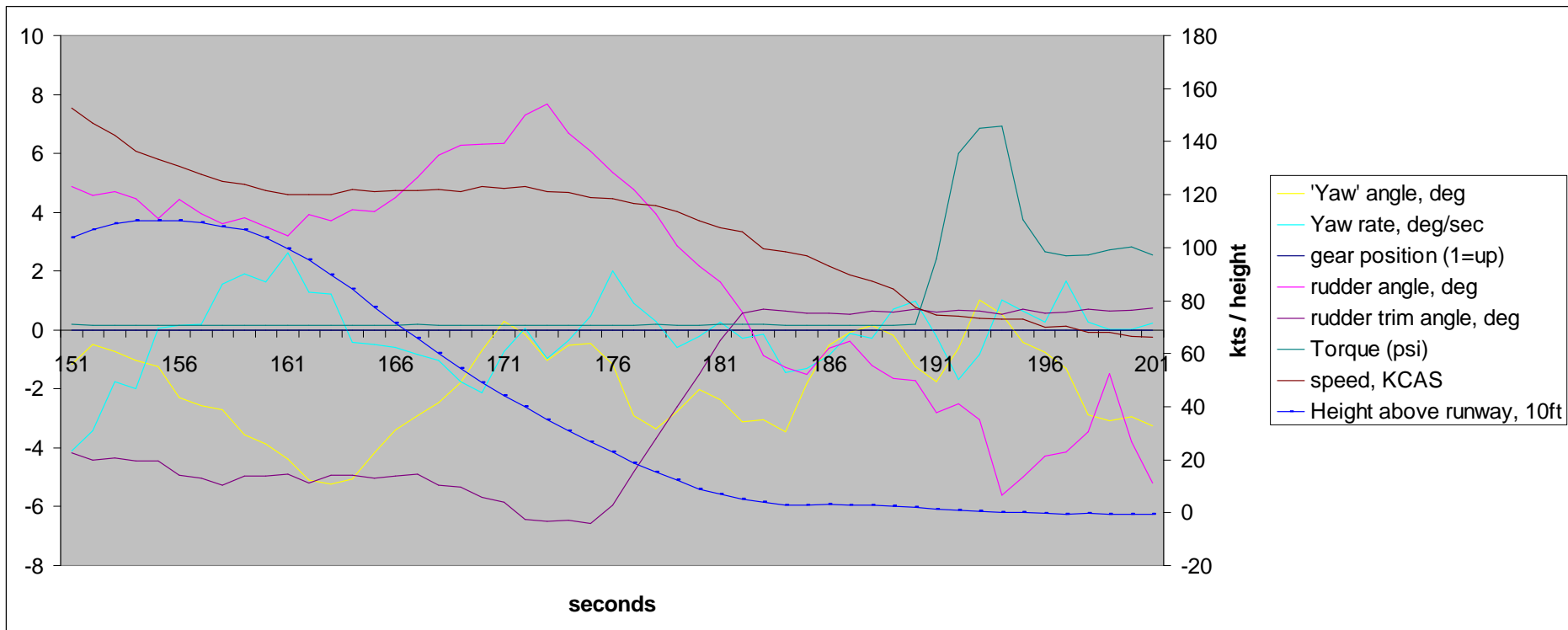Speed: ~ 120 knots
Rudder trim: full left

Figure 5, 50 seconds before touchdown

3   CONCLUSIONS

Pilatus have conducted dedicated flight tests using PC-12 SN 545. A similar flight path to the one of accident aircraft MSN 1020 was flown with auto-pilot/yaw-damper engaged. Full left rudder trim was required during the flight profile. The profile was flown using normal procedures. At no time was exceptional piloting skill required.

4   REFERENCES

[1]   ER-001868 "MSN 1020, Trim positions"

[2]   ER 12-22-11-004, "AFCS Functionality Report"

[3]   TCDS A78EU

[4]   Pilatus Doc. 02277, PC-12/47E POH/AFM